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XBT Surveys at Fieberling Guyot

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The effect of rough abrupt topography may have a number of effects on ocean currents including seamount-trapped waves, mixed layers and reflected internal waves. The possibility of seamount-induced subsurface mixed layers in the vicinity of Fieberling Guyot was investigated during several XBT surveys. From the R/V Atlantis II, during October 1990, XBTs were launched on two consecutive nights. Each night a four-pointed star pattern centered on the seamount and about 30 km across was completed. In addition, a star shaped XBT survey over and near the Guyot was finished over two 10-hour consecutive surveys. This second survey was accomplished in December 1990 from the R/V Atlantis II. The pattern was again centered on the seamount but extended about 40 km. In each survey XBTs were dropped at intervals of approximately 1 n.mi.

Mixing signatures near Fieberling's bottom topography was the focus of the search through the XBT profiles. Figures 1 and 2 are examples of mixed layer signatures found in the XBT profiles. The gradient of temperature change where a mixed layer exists is smaller then that above or below the mixed layer. In Figure 1, a mixed layer is observed from the depths of 425 to 475 m. Between the depths of 435 and 480 m. in Figure 2, a mixed layer is found. Each temperature profile between the depths of 350 and 600 meters was studied. Apparent mixed and inverted layers found in this region were noted and are demonstrated in Figures 3 and 4. The 109 XBT drop positions in October and the 126 drop locations in December are denoted by small dots on figures 3 and 4, respectively. Approximate bathymetry of Fieberling seamount shows the relative locations of the XBTs to the summit. The sizes of the noted mixed layers were used to categorize

the layer and are represented on the figures by symbols marking their locations.

From the October survey, mixed layers appear to the exist on all sides of the seamount. Those layers near the top and to the east of the guyot are larger than those occurring to the west of Fieberling. In the December pattern, occurrences of turbulent layers seem to be prevalent to the north and west of Fieberling's summit. Although more sparse and smaller, these layers also do exist to the southeast of the seamount. This agrees with the results of previous surveys that also showed mixed layers occurring on all sides but a stronger tendency for them to occur on the north and west sides of the guyot.

Several XBT transects over Fieberling were made during the April 24 - May 11, 1991 cruise on the R/V New Horizon. The first and third crossings were east to west transects over the three seamounts, Fieberling, Fieberling II and Hoke. The isotherm profiles of these crossings do not appear affected by the seamounts. However, the isotherm profiles from the second and fourth crossings, south-southwest to north-northeast transects over Fieberling, demonstrate a gradient in the 5 degree isotherm as it approaches and crosses the summit. North of the summit, the 5 degree isotherm occurs at depths between 670 and 700 meters. This isotherm rises in depth to approximately 550 m. just north of Fieberling's apex and then maintains this depth across and then to the south of the seamount. Although not nearly as pronounced, the 6 degree isotherm, at depths 450 to 500 meters, follows this same contour. On each of the south-southwest to north-northeast crossings, mixed layers were found on the northern side of the summit but not on the southern side.

The sea surface height variability in the region surrounding Fieberling was obtained using data from the Geosat altimeter. The raw GDR

(Geophysical Data Records) data containing Geosat's geodetic and first year ERM (Exact Repeat Mission) crossovers was used. Therefore, the length of the data set was longer than the data set, composed of only one year of ERM crossovers, used a year ago and the geodetic data provided more complete coverage than the ERM data alone. The orbit error, which was estimated as tilt and bias was removed by employing an iterative weighted minimum variance technique. The rms variability was then found within a diamond shaped region with Fieberling centered and an approximate radius of 5 degrees. In Figure 5, the results are given in contour form. The contour lines are labeled with the rms sea surface height variability in centimeters. The position of Fieberling is marked by a cross in the center of the figure. The rms sea surface height variability over the entire region is 7.4 cm. To the northeast of the seamount, the rms is higher with values generally over 8.5 cm and as high as 12.6 cm. Also, to the southwest of the summit, the rms values are less than 7.6 cm and as low as 5.1 cm. When this procedure was done using smaller regions (1/4 by 1/4 degrees) the results were approximately the same.

We are seeking a connection between the Geosat sea surface height rms variability and the mixed layer events through continued XBT measurement evaluation and further Geosat altimeter data time series analysis. Model development will aid in the comparisons and predictions.

Mixed Layers Occurring Between 350 and 600 Meters and Their Thickness

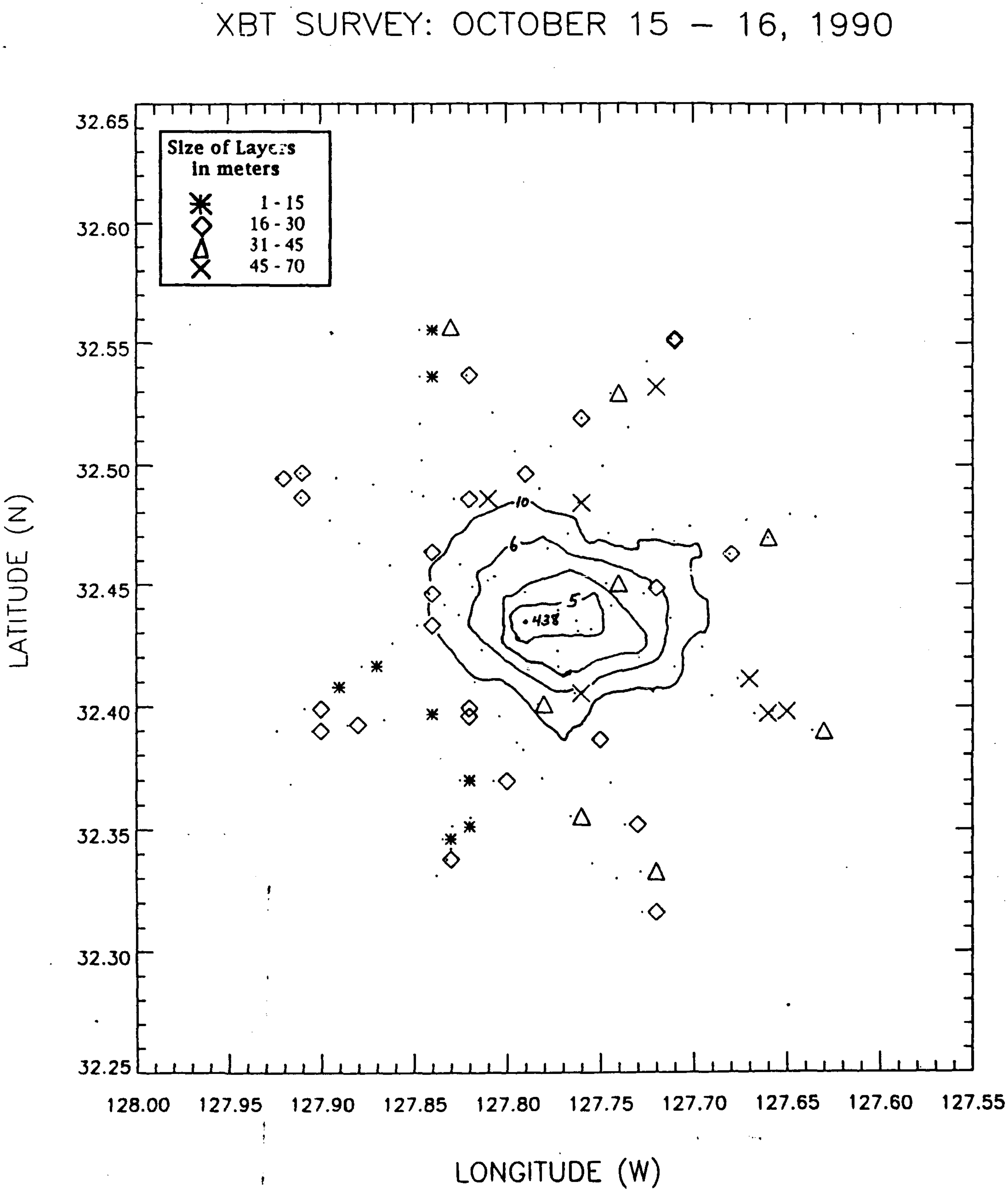

Figure 3

Mixed Layers Occurring Between 350 and 600 Meters and Their Thickness

XBT SURVEY: DECEMBER 4 – 5, 1990

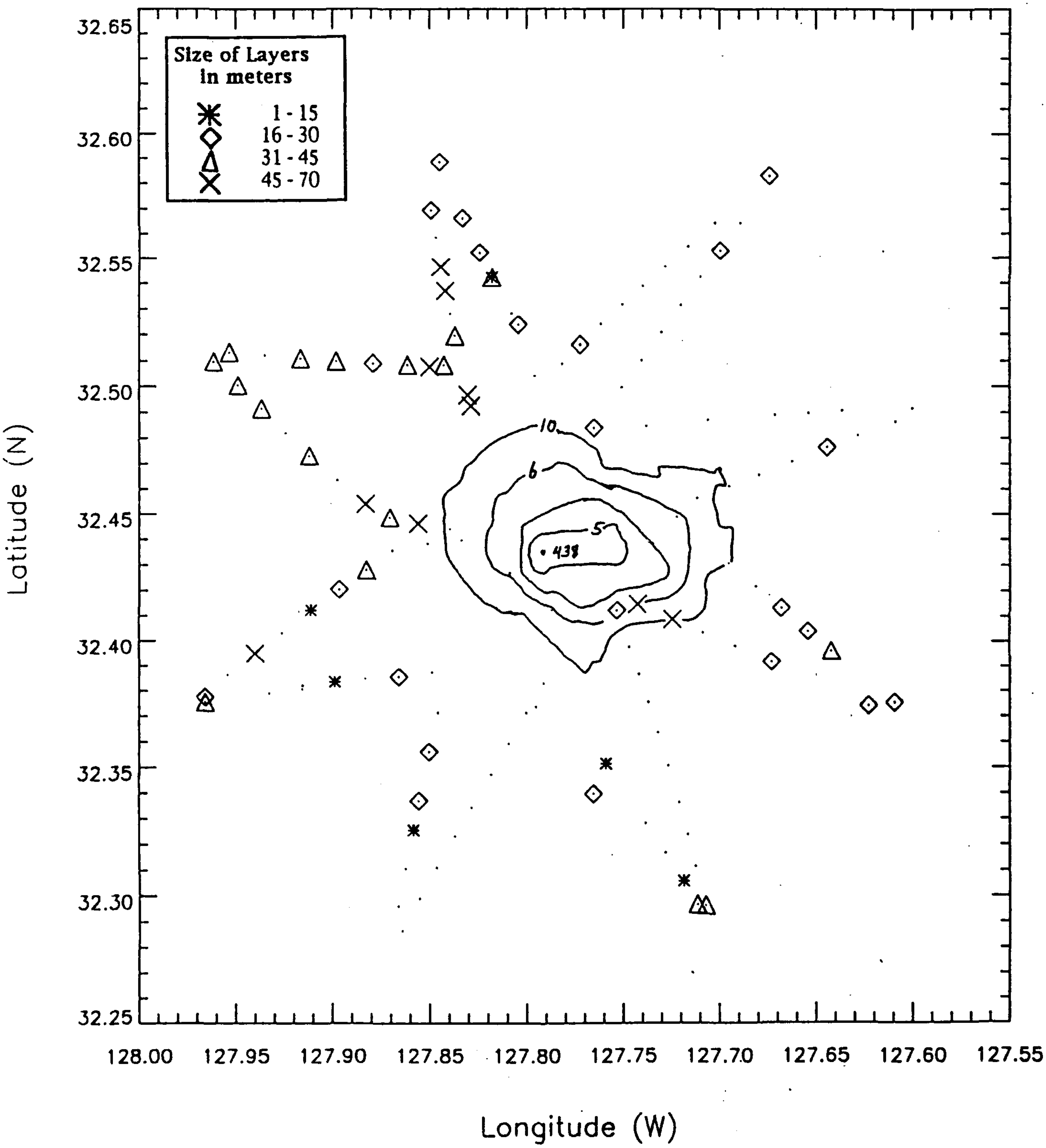

Figure 4

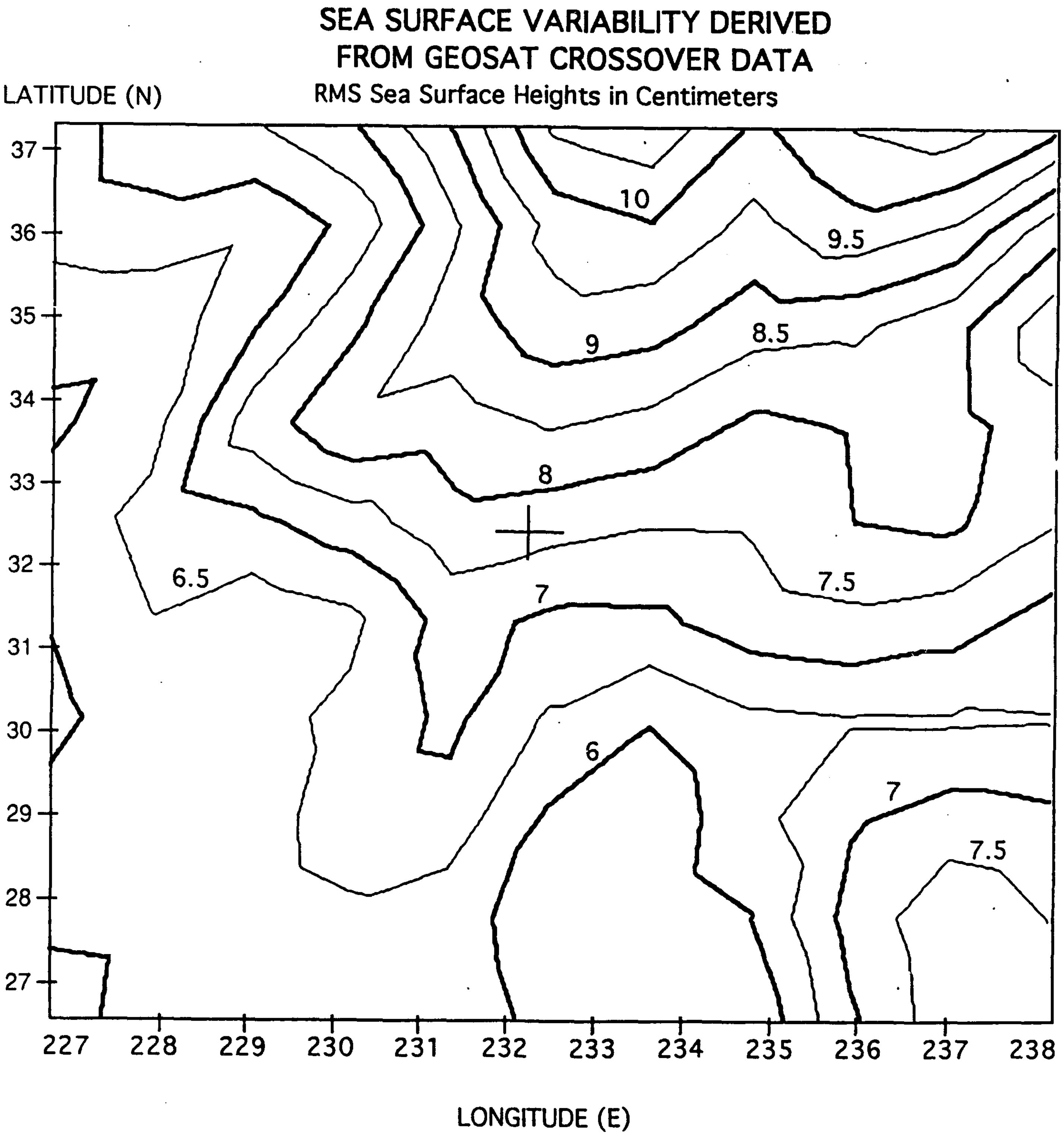
SEA SURFACE VARIABILITY DERIVED
FROM GEOSAT CROSSOVER DATA
LATITUDE (N)
RMS Sea Surface Heights in Centimeters
37
36
35
34
33
32
31
30
29
28
27
10
9.5
9
8.5
8
7.5
7
6.5
6
7
7.5
227
228
229
230
231
232
233
234
235
236
237
238
LONGITUDE (E)

Figure 5

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Mesoscale motions at Fieberling fm GEOSAT and XBT Data

Research Goals:

The primary goal of this program is to better use presently operating satellite remote sensing platforms for applications in physical oceanography. Specifically for this project the goal is to use altimetric remote sensing and expendable profilers to better understand the mesoscale flow structure around Fieberling Semount.

Objectives:
Our near term objective is to use the entire GEOSAT data set, in conjunction with all of the mesoscale XBT surveys we have collected, to better parameterize and describe the mesoscale circulation around Fieberling Seamount. Since there is little mean current in this area a proper description of the mesoscale currents is important for an understanding of the interaction between the circulation and the ocean topography. In addition we hope to be able to understand the existence of subsurface "mixed layers" expressed in the XBT vertical temperature profiles. We hope to determine if these mixed layers are formed as a result of the interaction between the Fieberling Seamount and the local mesoscale ocean circulation.

Approach:
At present all of the XBT surveys have been processed and have been optimally interpolated to yield uniform grids in spite of

the great variety of sample grids. These uniform grids are being analyzed to provide a space/time description of the mesoscale density and geostrophic current fields in the Fieberling region. We plan to use auto and cross correlations (and/or structure functions) to determine the fundamental length scales before computing wavenumber spectra for the region.

An additional analysis intended for the XBT surveys is to locate and map subsurface "mixed layers" expressed as small segments of the temperature profile with a relatively uniform vertical temperature gradient. These mixed layers may be expressions of the interaction of the seamount with the mesoscale circulation.

These wavenumber spectra (Fig. 1 average 2D wavenumber spectrum from the XBT surveys) will be compared with similar spectra computed from the GEOSAT altimeter data. To make the GEOSAT data more comprehensive we are processing the 3rd year of the ERM and will use a technique developed for a study of the Gulf of Alaska, that allows us to combine the ERM colinear data with the crossover data of the earlier Geodetic mission. This will extend the time series from 3 to 4 years, which will provide much more statistically stable estimates of the mesoscale surface height variations in the Fieberling region.

Finally we hope to do some simple modelling to add insight into the statistics derived from both the XBT and GEOSAT data fields.

Tasks Completed:
At present all of the XBT surveys have been collected (Fig. 2, summary of all XBT surveys), edited and processed to yield a consistent set of data for each period. In this year a set of 5 separate XBT surveys were collected on cruises of opportunity.

Collected in Oct., Dec., Mar., Apr. and June these surveys cover

a number of different seasons that will allow us to evaluate the seasonal changes in the mesoscale patterns. Due to operational constraints the final patterns of these various surveys differ greatly in detail. We have therefore optimally interpolated all of the surveys to generate a uniform grid in each case. These gridded data will be used to compute the various statistics to describe the mesoscale fields.

The orginal XBT data have been used to individually locate, statistically describe and map all of the subsurface "mixed layers" that appear as uniform portions of the vertical temperature gradient (Fig. 3, map of XBT mixed layers). These mixed layers may be caused by an interaction between the seamount and the mesoscale oceancurrents. We hope to better define this relationship.

The third year's data from the GEOSAT ERM have been processed and are being added to our 2 year time series from which previous analyses and animations were created. In addition we have a method that will allow us to incorporate the earlier crossover data from the Geodetic mission to extend our gridded time series from 3 to 4 years. This will make the analysis of the GEOSAT data more statistically significant and will allow us to look more closely at seasonal variations.

Due to a lack of coincidence it will be necessary to compare statistical parameters between the GEOSAT and XBT surveys. Some of the earlier XBT surveys were coincident with GEOSAT measurements but those XBT surveys from this past year were collected without an operational satellite altimeter. Unfortunately the Navy SPINSAT altimeter was cancelled.

Scientific Results:

The analysis of GEOSAT data has clearly showed the importance of the mesoscale circulation in the area around Fieberling Seamount. The regular propagation of Rossby waves past this location is a major feature in a related study of Rossby wave propagation in the Pacific (Jacobs et al., 92).

Space/time descriptions of the altimetric variability over Fieberling have also established the importance of the mesoscale over any possible mean circulation signal.

The XBT surveys all support this conclusion with both the temperature and inferred dynamic topography patterns being dominated by the mesoscale and smaller structures. No mean geostrophic flow is apparent from any of the 15 XBT surveys. We now need to better understand the similarities and differences between the mesoscale structures found in the XBT surveys and those found in the GEOSAT data.

A very interesting facet of the XBT data is the expression of subsurface "mixed-layers" with nearly uniform vertical temperature gradients. It may be that these uniform layers are caused by mixing at the Fieberling Seamount.

Accomplishments:
The most important accomplishment has been the mapping of the mesoscale structure around Fieberling from both XBT surveys and the GEOSAT altimeter data. The identification of subsurface mixed layers has also been important and it is hoped that we will be able to find a connection between their existence and the interaction bewteen the mesoscale currents and the seamount.

** Figures will be sent to ONR **

ONR-Sponsored Publications
References

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PS Jacobs, G.A., W.J. Emery and G.H. Born, 1991: Rossby waves in the Pacific Ocean extracted from GEOSAT altimeter data. submitted to J. Phys. Oceanog.

PI Biever, T.A., and W.J. Emery, 1992: Mesoscale phenomena around Fieberling seamount, (in preparation; to be submitted to JPO)

R Biever, T.A. and W.J. Emery, 1991: XBT Surveys at Fieberling Seamount, Topo News, #5, Aug. 1991

Statistics

1 Papers published, refereed journals
1 Papers submitted, refereed journals
0 Books or chapters published, refereed publication
0 Books or chapters submitted, refereed publication
0 Invited presentations
1 Contributed presentations
1 Technical reports and papers, non-refereed journals
2 Undergraduate students supported
2 Graduate students supported
C Post-docs supported
1 Other professional personnel supported

EEO/Minority Support

1 Female grad students
0 Minority grad students
0 Asian grad students
0 Female post-docs
0 Minority post-docs
0 Asian post-docs

Patents and awards

Influences:

The following are references that we have relied upon in this study:

Jenkins G.M. and D.G. Watts, 1968: Spectral Analysis and its Applications, Holden-Day, San Francisco, 525pp.

Haines, B.J., G.H. Born, G.W. Rosborough, J.G. Marsh and R.G. Williamson, 1990: Precise orbit computation for the GEOSAT exact repeat mission, J. Geophys. Res., 95, #C3

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Roden, G.I., 1991: Mesoscale flow and thermohaline structure around Fieberling seamount, J. Geophys. Res., 96, 16,653-16,672

Roden, G.I., 1977: On long-wave disturbances of dynamic height in the North Pacific, J. Phys. Oceanogr., 7, 41-49

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Action?